



CAFFEINE

Caffeine belongs to a class of compounds called methylxanthines. Caffeine is found in more than 60 plant species worldwide, including the berries of the guarana plant (*Paullinia cupana*), and is believed to help protect the plant from insect pests (Nathanson, 1984). Only a few of these plant species are commonly consumed by humans (IARC, 1991; Steffen, 2000). Caffeine is produced commercially by both extraction from plant material and by synthesis (IARC, 1991).

SOURCES

In the New Zealand diet, caffeine occurs naturally in coffee, tea, cocoa and foods containing these ingredients. Caffeine may be added to a range of beverages including energy drinks, energy shots, and kola type soft drinks. Guarana naturally contains caffeine and is added to some foods and as a source of caffeine.

POTENTIAL HEALTH EFFECTS

Caffeine has a range of both beneficial and potentially harmful effects. Beneficial effects of caffeine are increased energy, alertness, motivation and concentration. Common adverse effects associated with excessive central nervous system stimulation from caffeine ingestion include dizziness, rapid heartbeat, irritability, anxiety, tremors and insomnia. Irritation of the gastrointestinal tract can result in diarrhoea, nausea and vomiting (Durrant, 2002; Nawrot *et al.*, 2003). Caffeine may reduce bladder control for women (Nawrot *et al.*, 2003).

A single high dose of caffeine (4–6 mg/kg equating to 300–400 mg for an average male) can cause abnormally rapid heartbeat and increased blood pressure. The risk of high blood pressure associated with coffee consumption may be higher in certain genotypes (Palatini *et al.*, 2009). The evidence for an association between regular caffeine intake and cardiovascular disease is less clear (Stimulant Drinks Committee, 2002).

Tolerance to effects on blood pressure and heart rate, but not to sleep disturbance, develop quickly and virtually completely. A variety of withdrawal symptoms are described by most regular caffeine consumers who abruptly halt caffeine consumption, with

the most frequent symptom being headaches (Fredholm *et al.*, 1999; Meltzer *et al.*, 2008).

Individuals with inadequate calcium intake and a moderate caffeine intake (>400 mg/day) may be at risk of adverse calcium balance and impaired bone health due to increased calcium excretion (Nawrot *et al.*, 2003).

Caffeine intake during pregnancy is associated with an increased risk of foetal growth restriction. Consumption of caffeine at doses >300 mg/day may reduce women's fertility and increase the risk of miscarriage (COT, 2008; Nawrot *et al.*, 2003).

Only a few studies have considered the acute adverse effects of caffeine on children with caffeine reported to cause nervousness, jitters, stomach aches, nausea and depression (Luebke and Bell, 2009; Nawrot *et al.*, 2003; Smith *et al.*, 2000; Stimulant Drinks Committee, 2002). No studies have reported the potential chronic effects of caffeine consumption by children.

Death due to excessive caffeine ingestion is not common but has occurred. Fatalities have been associated with caffeine consumption in excess of 5 g (Garriott *et al.*, 1985; Kerrigan and Lindsey, 2005).

ESTIMATES OF DIETARY EXPOSURE

Most New Zealanders (73 percent or more) are exposed to caffeine from the consumption of coffee, tea, kola type soft drinks, chocolate and foods containing these ingredients. Exposure varies from <1 to over 1000 mg/day depending on age and preferences for these foods. When adjusted to body weight average exposures are estimated to range from 0.6 mg/kg bw/day for children (5–12 years) to 3.5 mg/kg bw/day for adults (20–64 years) (Thomson and Schiess, 2010).

The New Zealand estimates for average caffeine intake by children are similar to those from the USA and Denmark but lower than those for Argentina and the UK. For adults, the New Zealand estimates are higher than the USA, similar to those from the UK, and lower than those for European and South American countries (Barone and Roberts, 1996, Fray *et al.*, 2005, Olmos *et al.*, 2009, Rojo Camargo, 1999). Energy drinks or energy shots will have an additional impact on caffeine exposure. In New Zealand, the estimated average additional caffeine exposure, over and above

baseline dietary exposure, is approximately 4 mg/kg bw for children (5–12 years), 2 mg/kg bw for teenagers (13–19 years) and 1.6 mg/kg bw for young males (19–24 years) for each energy drink or energy shot consumed (Thomson and Schiess, 2010).

FACTORS INFLUENCING RISK

The caffeine content of coffee and tea beverages varies greatly depending on the preparation of the beverage. Therefore brand preference and beverage preparation will influence exposure and risk. For example, the caffeine content of the same coffee beverage obtained from the same retail outlet on six consecutive days varied from 259–564 mg/dose (McCusker *et al.*, 2003). The concentration of caffeine in teas ($n=203$) ranged from 1 to 90 mg per serving tea (FSA, 2004). The concentration of caffeine in instant coffees ($n=186$) ranged from 21 to 120 mg per serving and in brewed coffees ($n=106$) ranged from 15 to 254 mg caffeine per serving (FSA, 2004). Instant coffee has less caffeine than brewed coffee. Coffee perceived as strong has a higher concentration of caffeine than coffee perceived as weak (FSA, 2004). The volume of retail units and caffeine content of beverages containing added caffeine is variable. For example, energy drinks available in New Zealand at February 2010 ranged from 250 to 600 ml resulting in caffeine exposures of 75 to 240 mg caffeine per retail unit consumed. Energy shots ranged from 30 to 120 ml resulting in exposures of 10 to 300 mg caffeine per retail unit consumed (Thomson and Schiess, 2010). Hence the choice of energy drink or energy shot product will determine the level of caffeine exposure and risk of adverse caffeine effects.

SAFETY ASSESSMENTS

Several assessments of the safety of caffeine have been undertaken by:

- the International Agency for Research on Cancer (IARC, 1991).
- an Expert Working Group established by the Australia New Zealand Food Authority (now Food Standards Australia New Zealand) in 1999 (Smith *et al.*, 2000)
- Health Canada scientists in 2002 (Nawrot *et al.*, 2003)
- a Nordic project group under the Nordic Working Group on Toxicology and Risk Evaluation within the Nordic Council of Ministers in 2006 and 2007 (Meltzer *et al.*, 2008) who evaluated caffeine toxicity for children and adolescents and
- the Committee on Toxicity (COT) of Chemicals in Food, Consumer Products and the Environment who evaluated the reproductive effects of caffeine in 2008 (COT, 2008).

In 1991, the International Agency for Research on Cancer concluded that caffeine was not classifiable as to its carcinogenicity to humans (Group3) (IARC, 1991). Based on data up to 1999, (Smith *et al.*, 2000) concluded an adverse effect level of 95 mg (3 mg/kg bw/day in children aged 5–12 years with a mean bodyweight of 32 kg), and 210 mg in adults (3 mg/day for a 70 kg adult) based on observations of increased anxiety.

In their review, Nawrot *et al.* (2003) concluded that for the general population of healthy adults, moderate caffeine exposure of 400 mg/day (5.7 mg/kg bw/day for a 70 kg adult) was not associated with adverse effects such as general toxicity, cardiovascular effects, changes in adult behaviour, increased incidence of cancer or effects on male fertility. Based on limited evidence for altered behaviour, including anxiety (Bernstein *et al.*, 1994), the fact that the nervous system in children is continually developing, and the lack of information on long term effects of caffeine, an upper exposure of 2.5 mg/kg bw/day was suggested as a cautious toxicological limit on which to base risk assessments for children (Nawrot *et al.*, 2003). Reproductive-aged women should consume ≤ 300 mg caffeine/day (4.6 mg/kg bw/day for a 65 kg woman) (Nawrot *et al.*, 2003).

In a risk assessment of caffeine among children and adolescents in Nordic countries (Meltzer *et al.*, 2008), lowest adverse effect levels (LOAEL)s of 2.5 mg/kg bw/day and 1.4 mg/kg bw/day and 1.0–1.25 mg/kg bw/day were identified for anxiety, sleep disturbance and tolerance development, respectively. A no observed adverse effect level (NOAEL) of 0.3 mg/kg bw/day for caffeine tolerance development was identified.

The COT concluded that caffeine intake during pregnancy was associated with an increased risk of foetal growth restriction. Based on current evidence, it was not possible to identify a threshold level of caffeine intake below which there was no elevation of risk, although it seemed likely that risk was increased in association with intakes in the order of 200 mg/day and perhaps lower (COT, 2008).

SAFETY AND REGULATORY LIMITS AND REQUIREMENTS

Safety limits are levels of dietary exposure that are without appreciable risk for a lifetime of exposure. Regulatory limits define the maximum amount of a substance that is permitted in a particular food. Food regulations may also specify warning or advisory statements or directions for use or storage to be included on food labels for reasons of consumer health and safety.

Safety Limits

There is no recognised reference health standard for caffeine exposure, such as an Acceptable Daily Intake (ADI).

Regulatory Limits

Caffeine added to kola type soft drinks is regulated in Standard 1.3.1 “Food Additives” of the Australia New Zealand Food Standards Code. The maximum amount of added caffeine that is permitted in kola type soft drinks is 145 mg/L (or mg/kg).

Caffeine added to energy drinks is regulated in Standard 1.3.1 “Food Additives” and Standard 2.6.4 “Formulated Caffeinated Beverages” of the Australia New Zealand Food Standards Code. A formulated caffeinated beverage (such as an energy drink) must contain no less than 145 mg/L and no more than 320 mg/L total caffeine (including guarana).

Energy shots are currently regulated under the New Zealand Food (Supplemented Food) Standard 2010 (NZFSA, 2010). There are certain labelling requirements that apply if caffeine is added to energy shots at a level greater than what is required to achieve a technological function under conditions of Good Manufacturing Practice.

Labelling requirements

A formulated caffeinated beverage (eg energy drink) must be labelled with the amount of caffeine and an advisory statement which states that the food contains caffeine and is not recommended for children, pregnant or lactating women, and individuals sensitive to caffeine (Standard 2.6.4) (FSANZ, 2010).

If caffeine is added to a supplemented food (such as an energy shot) at levels greater than required to achieve a technological function under conditions of Good Manufacturing Practice, then the amount of caffeine and advisory statements that apply to formulated caffeinated beverages, must be included on the label (NZFSA, 2010).

Dietary advice

This section was updated in 2012 to include revised Ministry of Health recommendations for children and young people.

Pregnant women in New Zealand are advised to limit consumption of drinks containing caffeine with a maximum of six cups of tea or instant coffee, or three single espresso-style coffees daily (MoH, 2008). Energy drinks and energy shots are not recommended as they may contain high levels of caffeine and other ingredients not recommended for pregnant and breastfeeding women. (MoH, 2008; NZFSA, 2009).

Children and young people are advised to limit their intake of foods and drinks containing caffeine. More specifically, energy drinks and energy shots are not recommended for children or young people (MoH, 2012).

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